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X.

THE COMPANIONS OF PROCYON.

[*Communicated by Rear-Admiral C. H. Davis, Superintendent of the Naval Observatory, Washington.*]

Read, Feb. 9, 1876.

THE discovery in 1862, by Mr. Alvan G. Clark, of a companion of Sirius very near the place indicated by the theory proposed by Bessel to account for the variable proper motion of this star, naturally led astronomers to an examination of Procyon, a star which also has a variable proper motion. On March 19, 1873, a companion of Procyon was discovered by Mr. Otto Struve, Director of the Pulkowa Observatory, near the place indicated by the theory of Professor Anwers.

As soon as the 26-inch refractor of the Naval Observatory was ready for use, Professors Newcomb and Holden began an examination of Procyon, which has been continued, on convenient occasions, to the present time.

Struve's companion has not been seen by either of these astronomers ; nor, indeed, by any one who has examined the star through our instrument. Another companion, however, was soon suspected; and the existence of this and other companions has now been so well established that an account of the examination of this star will be interesting.

EXAMINATION OF PROCYON FOR THE DETECTION OF STRUVE'S COMPANION.

(*Extracts from Observing Books.*)

(1) 1873. Nov. 29. *Procyon* carefully examined, and all small stars within 2′ mapped down. STRUVE'S companion not seen. Seeing very good, except *possibly* a slight haze. Observer: NEWCOMB.

(2) 1873. Dec. 30. Examined *Procyon*. STRUVE'S companion not seen. NEWCOMB.

(3) 1874. Jan. 2. *Procyon's* distant companion measured. STRUVE'S companion not seen. NEWCOMB.

(4) 1874. Jan. 8. 13 h. 30 m. *Procyon:* examined carefully for about 20 minutes, — distant companion plain. Seeing good, and rays round star quiet: no small companion. Holden.

(5) 1874. Jan. 14. 10 h. Very good seeing at times: . . . no near companion to *Procyon*. Holden.

(6) „ Jan. 25. Seeing very excellent: . . . no near companion to *Procyon*. Holden.

(7) „ Feb. 5. *Procyon*. Good seeing. Struve's companion not seen. Newcomb and Holden.

Suspected a companion *following* more distant than companion to Sirius. Position angle 76° or 77°, by rough sketch. (See observations of Nov. 12, 25, and 26.) Holden.

(8) „ Feb. 14. *Procyon:* poor image. Holden.

(9) „ Feb. 21. 6 h. 15 m. to 7 h. *Procyon:* distant companion plain. *Procyon* unsteady, and poor seeing: no suspicion of near companion. Holden.

(10) „ Mar. 11. *Procyon:* no near companion. Holden.

(11) „ Mar. 20. 7 h. 30 m. *Procyon:* image good. Struve's companion not seen. G. W. Hough, Newcomb, and Holden.

(12) „ Mar. 21. 7 h. 30 m. *Procyon:* no near companion. Holden.

(13) „ May 18. About 8 h. *Procyon:* no near companion. C. H. F. Peters.

(14) „ May 26. *Procyon:* aperture reduced to 15 inches. Image poor: no near companion. Newcomb.

(15) „ Oct. 15. 17 h. *Sirius:* companion better seen with aperture reduced to 22 inches. — *Procyon:* aperture 22 inches. Struve's companion not found. Definition fine.

17 h. 44 m. Distant companion can still be bisected with ease in the increasing daylight.

17 h. 47 m. Bisection difficult, but companion plainly seen away from wire.

17 h. 51 m. Companion cannot be certainly seen at all. I am surprised at its sudden disappearance in the daylight. Newcomb.

[The sun was about 6° below the horizon at 17 h. 50 m.]

(16) „ Nov. 7. Cambridgeport, Massachusetts. Using the McCormick telescope; aperture, 26¼ inches. Seeing *very* good. *Procyon:* no trace of Struve's companion. Alvan Clark, G. Clark, and A. G. Clark.

(17) „ Nov. 12. *Procyon:* seeing about the same as at Cambridgeport [Nov. 7]. No sign of Struve's companion. Observation doubtful of a small companion $10''$ off, marked in drawing position angle = 68° from sketch. Alvan G. Clark, with 26-inch refractor at Washington.

(18) „ Nov. 25. 14 h. 30 m. to 15 h. 10 m. *Procyon:* seeing not *very* good. Struve's companion not seen. Small companion suspected. [p = 47° from sketch.]

15 h. 20 m. Reduced aperture to 22 inches; no better seeing. HOLDEN.

(19) 1874. Nov. 26. 15 h. *Procyon:* full aperture. I see distinctly the same companion that I saw last night. Position about 90° more than old companion. [$p = 42^\circ$ from this estimate.] Seeing *perfect.* Planetary disc to *Procyon.* 15 h. 30 m. to 45 m.: reduced aperture to 22 inches. Sudden scud of cloud and haze: saw the small companion but once. HOLDEN.

Besides the above recorded observations, the companion has been looked for and not found on various occasions at the Naval Observatory by Professors Hall, Eastman, and Peters; and by Professor Peters at the Melbourne Observatory with the four-foot reflector under very good conditions.

On Jan. 12, 1876, Procyon was examined under exceptionally fine circumstances by Professor J. C. Watson and Professor Holden. No trace of Struve's companion was seen; but both observers independently discovered others of which they at once, and without consultation, made sketches which agreed in showing certainly *three* small companions quite within 10″ of distance, and between 0° and 90° of position angle; and one was *suspected* by Professor Holden somewhere between the old companion and *Procyon.* Designating these in the order of position angle by 1, 2, 3, and 4, the sketches agreed in making 2 the brightest of the three, and also the most distant, while 1 and 3 were nearly of equal brightness and of equal distance (less than the distance of 2). The following is a transcript from the Observing Book: —

(20) *Procyon* and neighboring stars: coincidence of wires 64 r. 14 approximately. Telescope west of pier; eye-piece, 400 A.

Reading for Position.	Reading for Distance.	
231.6	63.488	
$p = 10^\circ$ $s = 6''$	63.592	
		J. C. WATSON.
200	63.31	
208	63.40	
$p = 34^\circ$ $s = 7''.9$		E. S. HOLDEN.
Telescope east of pier.	Eye-piece 400.	
209.6	65.12	
$p = 32^\circ$ $s = 9''.7$		J. C. WATSON.
208	65.02 eye-piece 400.	
$p = 34^\circ$ $s = 8.8$		E. S. HOLDEN.

No signs of Σ's companion: image fine. At about 11 h. Procyon examined by Professor J. C. Watson, and Holden. Where ALVAN G. CLARK found a companion (see Observing Book, Nov. 12, 1874), which was verified by Holden (1874, Nov. 25 and Nov. 26), Professors Watson and Holden found three. One of these is somewhat brighter than the other two (see sketches I. and II.), and this was first seen by Professor WATSON (i. e., on Jan. 12), while HOLDEN saw the *preceding* one; and, finally, all three were well seen, and the first seen was measured in both positions of the instrument east and west of the pier, by both observers. The seeing was extremely fine, and these images were well and steadily seen for about two hours (till 13 h.). In the sketches, *a* is the old companion, p = 312° [s = 42″].

SUMMARY.

Telescope W.	p = 10°	s = 6.″	J. C. W.
	p = 38	s = 7. 9	E. S. H.
	p = 34	. . .	J. C. W.
Telescope E.	p = 32°	s = 9.″7	J. C. W.
	p = 34	s = 8. 8	E. S. H.

Holden *suspects* a 4th companion somewhere about p = 320° — 330°. It should be noted further that 400 and 400 A are different eye-pieces, and that these satellites were seen in all parts of the field of view, and in all positions of the eye-piece.

(21) New companions to Procyon: 1876, Jan. 20. The seeing is not good.

Reading for position angle:

214°	HOLDEN	p = 28°
224	PETERS	p = 18
212	WATSON	p = 30
189°	PETERS	p = 53°
188	WATSON	p = 54
242°	PETERS	p = 0°

Saw the brightest of the three companions without difficulty and quite steadily, and caught occasional glimpses of one of the others. D. P. TODD.

Neither Peters, Watson, nor Holden see O.Σ's companion.

(22) Companions of Procyon: 1876, Jan. 21. 10 h. 11 m. Examined Procyon with power 400. Images generally blurred and flaring. Irregular whiffs of wind. During occasional moments caught quite distant glimpses of one or two companions about p 45° greater than old companion, but too unsteady to measure. [p = 357°] NEWCOMB.

About 11 P.M. saw, by glimpses only, two of the close companions of Procyon; viz., that nearest in angle of position to the old companion and the middle one. Procyon too much blurred to attempt any measurements. C. H. F. PETERS.

At 11 h. cannot be certain of seeing any thing in the place of the new companions, although there is at times something which looks like a companion. Images not good. HALL.

1876, Jan. 25. 10 h. 2 m. Procyon examined with powers 400 A, 400, 600 A, and single lens 500. I cannot see the new companions or Struve's. Distant companion seen steadily with all powers, but best with 400 A and 500. HALL.

(23) Procyon, 1876, Jan. 25. 10 h. 30 m. The new companion, i.e., the brightest of the three, suspected strongly, and a reading for position taken. Image of Procyon very poor. $p = 37.^\circ 0$. HOLDEN.

RECAPITULATION.

It seems to be established by the preceding observations that there is no companion to be seen in the position indicated by STRUVE. Collecting all estimates and measures of other suspected companions in a table, and adding a supposed identification of them with one of the *four* satellites suspected by Watson and Holden on January 12, we have the following: —

Date of the Observation.	Position of the Companion.	Distance of the Companion.	Supposed identification.	Observer.
1874. Feb. 5	76^{c}::	$s > 10''$	?	HOLDEN.
„ Nov. 12	68	10 est	?	A. G. CLARK.
„ „ 25	47	about 10	3	HOLDEN.
„ „ 26	42	„ 10	3	HOLDEN.
1876. Jan. 12	10	6	1	J. C. WATSON.
„ „ „	38	7.9	2	HOLDEN.
„ „ „	34		2	J. C. WATSON.
„ „ „	32	9.7	2	J. C. WATSON.
„ „ „	34	8.8	2	HOLDEN.
„ „ „	320°–330° ?	about 10	4	HOLDEN.
„ „ 20	28°	„ 10	2	HOLDEN.
„ „ „	18	„ 10	1 ?	PETERS.
„ „ „	30	„ 10	2	WATSON.
„ „ „	53	„ 10	3	PETERS.
„ „ „	54	„ 10	3	WATSON.
„ „ „	0	„ 10	1	PETERS.
„ „ 21	357 (est)	„ 10	1	NEWCOMB.
„ „ 25	37	„ 10	2	HOLDEN.

The three companions about which no doubt is entertained are, —

1. $p =$ about 10° $s = 6''$
2. $p = 36^\circ$ $s = 8''8$
3. $p =$ about 50° $s < 10''$

It is quite possible that there may be one or two more. It is easy to understand why these have not been seen before, as the early examinations were principally for the purpose of detecting the existence of STRUVE's companion, and as the very finest atmospheric conditions are required for their certain detection. It is believed, however, that even in ordinarily good seeing *two* can be seen.